COLLEGE FRESHMAN BIOLOGY TWO-SEMESTER COURSE: INTEGRATING DEEP PROCESSING TEACHING TECHNIQUES

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Development of a college level freshman biology course was undertaken in response to government reports that American students have fallen behind students of other countries in the area of the sciences. Teaching strategies were investigated to accomplish two objectives, to define essential academic material to include in the course and to investigate teaching techniques that would increase deep processing of the information. An active process that consisted of applying the cognitive information to solving problems or developing answers to questions was defined as critical thinking. Critical thinking was incorporated into the course by the use of case studies.

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CHAPTER I

Introduction

Literature Review

"It is nothing short of a miracle that the modern methods of instruction have not yet entirely strangled the holy curiosity of enquiry." –Albert Einstein

The United States House Committee on Science (1998) and Richard W. Riley, Secretary of the United States Department of Education (1998) have released documents about science education in the United States. Two items that were revealed include:

1. The science and math backgrounds of our incoming freshmen (recent twelfth grade graduates) are inferior when compared to students of other countries.

2. Our graduate science and math programs are the best in the world and international students come to the United States to become educated at the doctorate level. This leads to the conclusion that the United States is not motivating and/or training our own students in the sciences but, are able to offer world class education at the most advanced levels.

Students who are enrolled in medicine, dentistry, nursing and allied health fields are required to have a basic comprehension of the science of biology. Biology is often the groundwork for many fields of study in addition to the pure biological sciences which includes many topics such as cellular respiration, cell division, and the origins of life. These topics require more than simply rote memorization of facts. Abstract thinking is needed to fully understand the concepts.

An understanding of how the human brain processes information may provide insight into teaching techniques that increase student comprehension. All human brains process information in the same way (with the few exceptions). Erickson and Strommer (1991) have reviewed how the human brain stores information. The first exposure to information results in storage in short-term memory. Our brain is storing it here for just a few seconds to allow us to comprehend it. When meaning can be made of the information it is moved to long-term memory. Once the information is in long-term memory it must be stored in a way that can easily be retrieved for future use. If the information is stored with a meaningful concept, it can be accessed more easily at another time.

There is a difference between surface processing and deep processing. Surface processing describes what happens when data are learned through strict memorization. The ability to retrieve information stored in long-term memory in this fashion is much more difficult. The information has been stored without being connected to meaningful concepts. Deep processing of information on the other hand is stored in long-term memory as a result of connecting meaning to the information. This information becomes connected to other data in a fashion that allows for much easier access to it in the future. An ideal learning situation would result in deep processing of information allowing students a foundation of knowledge that they can build on for future courses and experiences.

Erickson and Strommer (1991) make the statement that instructors can either encourage or discourage the process of deep processing. It has been found that when students have learned a science concept incorrectly, they tend to continue that line of thinking even into advanced science courses. Students who have been taught the same

concept in many classes but initially learned it incorrectly or with gaps, tend to continue with incorrect thinking. The methods used to present information and evaluate the students' understanding of the information are extremely important to allow progression to higher levels of correct understanding of science.

We may have to help students to re-think what learning is. A student may equate learning with knowing the data by memorization and understanding of specific examples given in class. Erickson and Strommer (1991) have given several examples on ways to organize a lecture to encourage deep processing of information. To discourage "passive listening, verbatim note-taking, and superficial information processing" these authors suggest changing the format of lecture style from "the nonstop fifty minute lecture". They suggest presenting information for 10-15 minutes and then providing lecture time

An advanced degree in the designated field of study is required to teach at the college level. The skills to effectively impart knowledge to college level students are often not part of a graduate degree. Effective teaching methods often are learned by trial and error while on the job. For individuals with the intention of teaching at the college level, preparation in teaching strategies would be of great benefit.

It is much less stressful on the instructor to expect surface processing of information only and evaluate student learning in this manner. However, it has been shown that students who do not learn difficult concepts very well in freshmen level courses will usually continue to have difficulty with these concepts throughout their education, even into upper level courses.

Erickson and Strommer (1991) have given several examples on ways to organize a lecture to encourage deep processing of information. To discourage "passive listening, verbatim note-taking, and superficial information processing" these authors

suggest changing the format of lecture style from "the nonstop fifty minute lecture". They suggest presenting information for 10-15 minutes and then providing lecture time for students to process the information. An example of an activity to do that would be providing a problem for students to solve. There is validity to this approach as McKeachie (as cited in Erickson & Strommer 1986) reported that as a lecture continues, students remember less and less of the lecture. The last ten minutes of the lecture result in only 20% retention.

Guiding students in note-taking can prove beneficial to the student to help them understand how the instructor will be evaluating them on future projects and tests. Discouragement of verbatim note-taking is a difficult habit to break in the student, but certain steps, conducted by the instructor, can help the student. The following recommendations to improve students' note taking abilities include:

1. Identify the topic(s) to be covered as well as how the students will be held responsible for the information.

2. Emphasize the major ideas of the lecture.

3. Use problems, examples, and illustrations to emphasize the topics. In using examples make it clear how the example relates to the topic.

4. Summarize with a strong conclusion that repeats what was in the introduction of the lecture.

5. Assignments are recommended as further practice for the students to allow them to use the information discussed (Erickson and Strommer 1991).

Deep processing of information is increased when meaning is integrated with information. It seems reasonable to conclude that providing opportunities for students to use critical thinking skills would give additional meaning to the facts the

students need. Chiras (1992) has summarized eleven "principles of critical thinking". He believes that critical thinking skills will carry over to analyzing situations in daily life. The principles are explained in more detail but, are summarized as:

Gather complete information.

Understand and define all terms.

Question the methods by which facts are derived.

Question the conclusions.

Look for hidden assumptions and biases.

Question the source of the facts.

Don't expect all of the answers.

Examine the big picture.

Examine multiple cause and effect.

Watch for thought stoppers.

Understand your own biases and values.

To provide students with the information to review before class the use of Study Sheets was developed by Schearer (1988). These are similar to the current technique used of providing lecture notes in outline format but, with some differences. The material is outlined to identify the subject material deemed essential to learning. Included on the study sheet are assigned problems, which describe how the student is to use the knowledge gained.

To use these Study sheets the student is to review the outline using the text. The student is to note the definition of unfamiliar terms, describe any processes and note any areas of confusion on the study sheet. This will be the first review of the material. The assigned problems are to be completed before class.

The amount of information that can be expected of students to acquire is overwhelming. Students cannot memorize the text so usually try to determine what the instructor thinks is important and then to study that information for testing purposes. In this scenario rote learning is encouraged as well as a little bit of intuition in determining what the instructor will ask. The ideal scenario involves students coming to class having already reviewed the material for the lecture. The instructor then need not "cover" the text but, instead discuss issues, difficult information, and answer questions.

Much has been written about the use of case studies in teaching situations. Case studies present a certain situation to the student, who is then required to develop an answer or a decision concerning the case. They have been used by business schools to provide students with the experience of making a decision about a situation. The learning experience involves much more that rote learning. The student often must do some research on the case and develop a course of action. In medical schools case studies have been used in a model called Problem-Based Learning. In this case, the student must attain a certain level of science knowledge in order to make a medically related decision regarding the case. (Waterman, 2001)

Using a type of case study method in the teaching of biology has been suggested in the literature by Chiaras, Waterman et.al. Waterman describes an "investigative case-based approach". She states an important aspect of this approach involves learning in groups where discussions occur about the case study. The BioQuest Currriculum Consortium is a group of biology instructors whose purpose is to develop the mechanics of using case studies in teaching. The case study approach might involve one extended study through out the semester or short studies that are completed during lecture time. It

may require the students to totally develop an approach to a problem including investigative questions to ask and researching the possible solutions.

The Problem

The problem, which was the focus of this thesis, concerned the development of the format of the lecture portion of a one-year freshman biology course. The problem was identified through previous reports concerning teaching of the sciences to American students and the authors' desire to develop a course incorporating teaching methods that would provide students with opportunities to associate meaning to facts. The problem focuses on two aspects. First; identification of the necessary concepts to include in the course and second; incorporating teaching techniques that required the student to use critical thinking skills.

CHAPTER II

Development of Freshman Biology Course

Course Content

The information included in the course was identified through review of the most current editions of three different college biology texts. The author acknowledges that textbooks, even those published in the current year, cannot include research results that occur following publication. Textbooks also may not provide the desired depth of a subject. Review of current textbooks does however provide a framework to develop a course curriculum from. This framework can be then be expanded further with the most recent findings from up to date sources. Teaching students the most current information is always one of the challenges of science instruction.

The author owned the most recent edition of Biology by Campbell, Reece, and Mitchell. The publishing houses provided Biology The Unity and Diversity of Life by Starr and Taggart and Biology by Mader. The texts were reviewed for subject content, order of content presentation, depth of content coverage, and supplementary materials. A student outline on each major biology section included in the two-semester course was developed. The outline was developed in standard topic format with the major topics listed as primary outline headings. Additional subheadings were listed under each primary heading that further detailed information on that topic.

This outline included only topic headings and was not intended as a substitution for lecture notes. The outline provided the student with a guide that identified the information to be learned. The student was instructed at the beginning of the semester on how to use the outline. The student could use the outline with the text to initially identify the required information. The instructor's lecture followed the outline and provided the

details. The outlines provided the students with a written guide to the instructor's lecture for each class.

Student Use of Outlines

The lecture outlines are placed on reserve in the library for students to obtain personal copies prior to class lecture. The purpose of the outline is to provide a guide in identifying what information is essential for comprehension. Class time consists of a review of the outline material but, not necessarily of every item on the outline. Students will be informed that class time is to be used to clarify any aspects of the outline that may need further clarification. The instructor reviews the topics students typically need additional exposure to besides reading of the text. It is also be a time when students are encouraged to ask their questions. Students are strongly encouraged to review the outline and text prior to the lecture to get full benefit from class time.

Critical Thinking Defined

A review of literature on critical thinking was conducted which resulted in a working definition used for this thesis. Critical thinking has been defined in various ways by a number of authors. For this thesis critical thinking was defined as an active process that consisted of applying the cognitive information learned in solving problems or developing answers to questions. Applying the appropriate information to solve the problem/answer questions required skills that are more advanced than rote memorization. Terms such as; explain, why, how and discuss were used in the problem/question instead of terms such as list, state, or define.

A Workable Case Study Concept Identified

Each case study consisted of instructor guidelines and student guidelines. The instructor guidelines consisted of goals and lecture information necessary to provide to the student prior to the case study. The goals identified what the student was expected to be able to do on completion of the case study. The student guidelines consisted of a statement of the problem and stated questions regarding the problem. The case studies were developed keeping in mind the restraints of class time and student skills. Case studies were short allowing students to complete them in two class periods.

After a presentation of the information identified in the lecture the case study was distributed to the class. The class then broke up into small groups to review the problem and clarify the focus of the problem. The instructor was available to assist groups on any further clarification needed in comprehending the nature of the problem. The students then assigned specific questions to each group member. Students were responsible for providing an answer(s) to their questions the following class period.

The next class period the students met in their groups to discuss the questions. Each individual presented their responses to the questions to their group. The student was responsible to justify to their group their response to the question. The group came to a consensus on the response believed appropriate to answer the question. Each group was randomly assigned a question to present to the class. The instructor served as a facilitator in evaluating the appropriateness of the response and to lead discussion regarding the response. The student was led through the process of critical thinking by:

1. Identification of information needed through lecture and text
2. Exposure to questions that led to a solution
3. Peer discussion.

CHAPTER III

Case Studies

Case Study: Gene linked traits

Introduction: Mr. B is red-green colorblind. He has four grandchildren, two boys from his daughter and two girls from his son. Both of his children are not colorblind.

Problem: He wonders how it is possible that of his four grandchildren none are colorblind.

Questions:

-What are the possible genotypes of the children?

-If the son is not colorblind what is the genotype of the mother in the P generation.

-Draw a punnet square showing the F1 generation.

-Explain if any of the children in the F1 generation were carriers of color blindness.

-Explain how the sons (F2 generation) of Mr. B's daughter are not colorblind. Use a punnet square to justify your answer.

-Explain the possible genotypes of the girls of the F2 generation. Use punnet squares to justify your answer.

Instructor Guidelines:

Lecture prior to case study

-Use of punnet squares

-Sex linked traits

Goals for students:

-Comprehend how sex linked genes are passed to the following generations.

-Know why males express sex linked genes more often.

-Understand how to use punnet squares to determine genotypes of offspring.

Case Study: Photorespiration

Introduction: Some studies have suggested that the increased use of fossil fuels is increasing the amount of carbon dioxide in the earth's atmosphere. One of the proposed consequences of the increased carbon dioxide is an increase in global temperature.

Problem: Can an increase in carbon dioxide have any effect on crop plants?

Questions:

-How would an increase in carbon dioxide affect the amount of time that the stomata would be open or closed?

-How would this effect the amount of water lost through transpiration?

-Explain if an increase in temperature from the carbon dioxide has any effect on transpiration.

-Explain if an increase in carbon dioxide would affect the water needs of crop plants.

Instructor Guidelines:

Lecture prior to case study

-Process of photorespiration

Goals for students:

-Understand how water loss and gas exchange is controlled in plants.

-Know what effects differing levels of carbon dioxide and oxygen have on crop yield in C3 plants.

-Explain how temperature effects the guard cells.

Case Study: Multiple sclerosis (MS)

Introduction: MS is a central nervous system disease that worldwide affects 250,000 to 350,000 people. It occurs more often in Caucasian women who are 20-40 years of age and live above the 40^{o} latitude. This is a chronic disease that is a result of demyelination. An individual with a science background has just been diagnosed with multiple sclerosis.

Problem: It is your job as a health care educator to explain to the patient what the disease MS and to answer the patients' questions.

Questions:

-How do the nerves send electrical impulses from the brain to the rest of the body?

-Why is MS called a neurological disease?

-Explain what happens to the nerves in the disease by including a description of the anatomy of the nerve cell.

Instructor Guidelines:

Lecture prior to case study

-Anatomy of nerve cell

-Organization of neurons

-Membrane potential

-Action potential

Goals for students:

-Comprehend how muscle cell receives messages from the nervous system.

-Understand the effect that demyelination has on muscle function.

Case Study: Antibiotic Resistance

Introduction: *Staphylococcus aureus* has been identified as one of the bacteria that causes infections in hospital settings. Several antibiotics have been discovered that can kill these bacteria including penicillin, methicillin, and vancomycin. In the late 1990's it was shown that this bacteria is 98% resistant to penicillin and 32% resistant to methicillin. The first strain of *Staphylococcusaureus* that showed some resistance to vancomycin was identified in 1996 in Japan and in 1997 in the United States.

Problem: Explain why strains of harmful bacteria are becoming resistant to antibiotics that were previously effective in killing the bacteria?

Questions:

-Explain the general effect antibiotics have on bacteria?

-Explain how antibodies are developed in the body.

-Discuss what some of the causes of antibiotic resistance are.

Instructor Guidelines:

Lecture prior to case study

-Basic concepts of humoral response

-Effects of antibiotics on bacteria

Goals for students:

-To understand how the body responds to harmful bacteria.

-To understand the basic concepts of how antibiotics work in destroying bacteria.

-To understand why bacteria are becoming resistant to existing antibiotics

Case Study: Sickle cell anemia

Introduction: A young African-American girl has run a long race in a late morning gym class. Soon afterwards she feels unusually fatigued and remains lethargic for several hours. After visiting the school nurse, she is sent home for the day. She is drowsy, feels tired and weak, complains of pain in her arm and leg muscles, has shortness of breath and has a blueness to her lips and palms.

Problem: A blood workup shows she has a low level of hemoglobin, many red blood cells that are hooked shape, and an abnormal form of hemoglobin.

Questions:

-Describe why the abnormal blood work up explains the symptoms of fatigue, shortness of breath and a blueness of the skin.

-Explain the genotype the young girl must have since the disease sickle cell anemia has been expressed.

- Determine what the possible genotypes of the girl's parents would be when neither parent has the disease.

-Determine if the girl's offspring would also have the disease.

Instructor Guidelines:

Lecture prior to case study

-Recessively inherited disorders

Goals for students:

-Understand how recessive disorders are passed to offspring from normal parents.

-Know how to determine if the offspring would inherit a trait.

Adapted from A Case Study by William H. Cliff, Niagara University, NY.

CHAPTER IV

Semester I Outlines

Introduction to Biology

- Biological organization
  - Emergent properties
  - Organisms to biospheres
  - Atoms to organisms
- Energy flow
- Nutrient flow
- Cell types
  - Prokaryotic
    - Eubacteria
    - Archaeabacteria
  - Eukaryotic
- Living organisms
  - Diversity and unity
  - Taxonomic groups
  - Three domains
  - Six kingdoms
- Scientific method
  - Deductive and inductive reasoning

Chemistry of Life

- Molecular level of Biology
  - Chemical elements
    - Pure, trace, and compounds
  - Atoms
    - Subatomic particles: neutrons, protons, electrons
    - Atomic measures: atomic number, atomic mass versus atomic weight
    - Isotopes
      - Radioisotope application in biology
  - Electron configuration
    - Energy levels
    - Orbitals
    - Valence electrons and octet rule
  - Chemical bonds
    - Covalent bonds
      - Electronegativity
        - Nonpolar versus polar covalent bonds
    - Ionic bonds
      - Electronegativity of acceptor versus donor atom
    - Hydrogen bonds

- Chemical reactions
  - Reactants to products
  - Chemical equilbrium

Water molecules

Polarity

Hydrogen bonding

pH scale

Properties of acids and bases

Buffers

Chemical reactions/chemical equations

Water

Principles of water

Polarity of water molecules result in properties of water

High surface tension of water

Cohesion

Bodies of water on planet contribute to maintenance of temperature

Specific heat of water

Evaporative cooling

Heat of vaporization

Density is less as a solid

Formation of hydrogen bonds forms crystal lattice

Solvent

Hydrophilic substances-ions and polar compounds dissolve in water

Hydrophobic substances-nonpolar compounds

Dissociation of water

$H_2O \rightarrow H^+ + OH^-$

pH

Definitions

Neutral solution

Acidic solution

Basic solution

Acids and bases

pH scale

Buffers

Carbonic acid-bicarbonate buffer system

$CO_2 + H_20 \rightarrow HCO_3 + H^+$

Carbon Chemistry

Monomers, polymers, macromolecules

Hydrolysis

Condensation

Carbohydrates

Atoms and chemical structure

Monomers

Polymers

Macromolecules

Lipids

Atoms

Chemical structure

Saturated versus unsaturated

- Triglycerides
- Phospholipids
- Sterols

Proteins

- Atoms
- Monomers
- Polymers
  - Peptide bonds
- Macromolecule

Nucleic Acids

- Atoms
- Monomers
- Macromolecules
  - DNA and RNA

Macromolecules

Macromolecules

- Four classes
- Condensation
- Hydrolysis

Carbohydrates

- Atoms and characteristics
- Major groups
- Sugars

- Monosaccharides
- Disaccharides
- Polysaccharide
    - Storage polymers: starch and glycogen
    - Structural polymers: cellulose and chitin

Lipids

- Atoms and characteristics
- Major groups
    - Triglycerides
        - Glycerol
        - Fatty acids
            - Saturated versus unsaturated
            - Hydrogenated
    - Phospholipids
    - Steroids

Proteins

- Atoms and characteristics
- Amino acids- monomer of protein
    - Side chains
- Polypeptides
- Conformation determines function
- Protein structure
    - Primary structure
    - Secondary structure

Tertiary structure

Quaternary structure

Denaturation of protein

Protein folding sequence

Recent developments

Nucleic Acids

Atoms and characteristics

Nucleotides-monomer of nucleic acids

Composition

Nitrogenous bases

Pyrimidines

Purines

Deoxyribonucleic acid (DNA)

Ribonucleic acid (RNA)

Introduction to Metabolism

Metabolic reactions

Catabolic reactions

Anabolic reactions

Coupled metabolic reactions

Energy

Kinetic energy

Potential energy

Laws of thermodynamics

- First law of thermodynamics
- Second law of thermodynamics
    - Entropy

Free energy

- Importance
- Exergonic reactions
- Endergonic reactions

Measure of energy

- Kilocalories
- Kilojoules

Energy needs for cellular work

- Types of cellular work
    - Mechanical
    - Transport
    - Chemical

Energy source for cellular work

- Macromolecules
- Intermediate carrier-adenosine triphosphate (ATP)
    - ATP structure
        - Unstable phosphate bonds
- Coupled reactions
- Regeneration of ATP
    - Cellular respiration

Enzymes

General characteristics

Proteins

Increase reaction time

Substrate specific

Substrate

Active site

Induced fit

Catalytic cycle

Enzyme-substrate complex

Induced fit results in conversion of substrate to product

Enzyme and product separate

Environmental effects on enzyme activity

Temperature

pH

Cofactors

Inhibitors

Competitive

Noncompetitive

Control of metabolic reactions

Enzyme activity

Activators bind to allosteric site of enzyme

Inhibitors bind to allosteric site of enzyme

Feedback inhibition

Cooperativity

Cells

- General Cell characteristics
    - Common features
    - Prokaryotic versus eukaryotic
    - Surface to volume ratio
- Compartmentalization of eukaryotic cells
    - Advantages
- Eukaryotic cell compartments
- Nucleus
    - Genetic information
    - Nuclear envelope
    - Nucleolus
    - Protein synthesis control
- Ribosome
    - Formation
    - Location
    - Function
- Endomembrane system
    - Nuclear envelope
    - Endoplamic Reticulum (ER)
        - Structure differences of smooth and rough ER
        - Functional differences of smooth and rough ER
    - Transport vesicles

- Golgi Apparatus
  - Structure
    - Movement of ER products from cis to trans face
  - Lysosomes
    - Function
  - Vacuoles
    - Functions

Additional organelles

- Mitochondria of bacteria and animal cells
  - Structure
  - Function
- Chloroplast of plant and algae cells
  - Structure
  - Function

Cytoskeleton

- Function
- Fibers-structure and function
  - Microtubules
  - Microfilaments
  - Intermediate filaments

Intracellular Junctions

- Plasmodesmata in plant cells
- Animal cell junctions-structure and function
  - Tight junctions

Desmosomes-anchoring junctions

Gap junctions

Cell Membrane

Function

Barrier around cell

Selectively permeable

Structure

Membrane fluidity

Fluid mosaic model

Phospholipids

Proteins

Unsaturated hydrocarbon tails

Temperature

Cholesterol

Spatial arrangement of proteins

Integral proteins

Peripheral proteins

Cell-cell recognition

Movement across the membrane

Selective permeability

Transport proteins

Passive transport-Diffusion across cell membrane

Concentration gradient

- Net directional movement
- Osmosis
  - Osmotic concentration: hyper-, hypo-, isotonic
  - Osmotic pressure
  - Biological fluids-unbound versus bound water
  - Water balance in cells
    - Cells without cell walls
    - Cells with cell walls
- Facilitated diffusion by transport proteins
  - Change in protein conformation
  - Selective channels
- Active transport
  - Sodium-potassium pump
  - Cotransport of two solutes
- Membrane potential in transport of ions
  - Electrochemical gradient
  - Electrogenic pump
- Transport of large molecules
  - Endocytosis
    - Phagocytosis, pinocytosis, receptor-mediated
  - Exocytosis

Cellular Respiration

Process overview

- Fermentation
- Cellular respiration
- Role of ATP
- Oxidation-reduction (redox) reactions
    - Oxidation versus reduction reactions
    - Electronegative atoms
    - Cellular respiration as a redox reaction
- Oxidation of glucose in small steps versus one large step
    - NAD as electron acceptor
    - Electron transport chain role
        - Oxidative phosphorylation
    - Oxygen as highest electronegative acceptor

Processes of cellular respiration

- Glycolysis
    - Location in cell
    - Exergonic and anaerobic process -Glucose oxidized to pyruvate
        - Energy requiring phase
            - Five chemical reactions result in 2 molecules from glucose
            - Intermediates phosphorylated by ATP requiring 2 ATP molecules
        - Energy yielding steps
            - ADP phosphorylated to produce 4 ATP molecules
            - NAD^+ reduced to produce 2 molecules of NADH
- Krebs cycle

Location in cell

Exergonic and aerobic process-pyruvate completely oxidized

Acetyl CoA formation

CO_2 formed

NAD^+ oxidized to NADH

Eight chemical reactions of one turn of the cycle result in

Two molecules of CO_2

3 NADH and 1 $FADH_2$ molecules are formed

One ATP molecule is formed

Electron transport chain

Oxidative phosphorylation-endergonic process

Electronegativity of carriers in chain

Proton gradient generated

Chemiosmosis

Exergonic electron transport chain coupled with endergonic ATP production

Proton motive force/electrochemical gradient

Chemical gradient based on proton concentration

Electrical gradient based on charged protons

Net ATP production from a glucose molecule

Glycolysis

Oxidation of pyruvate

Krebs cycle

Fermentation

- Alcohol fermentation
- Lactic acid fermentation

Photosynthesis

- Nutrition-attainment of organic molecules
  - Autotrophic nutrition
    - Photoautotrophs and chemoautotrophs
  - Heterotrophic nutrition
- Chloroplasts
  - Structure
    - Outer double membrane
    - Thylakoid
    - Stroma
- Process overview
  - Comparison to cellular respiration
  - Light reactions result in photophosphorylation
  - Calvin cycle results in carbon fixation
  - Results are production of ATP, NADPH, and O_2
- Properties of Light
  - Electromagnetic energy
  - Photons
- Photon absorbing pigments of photosynthesis
  - Chlorophyll a
  - Accessory pigments

Processes of photosynthesis

- Photoexcitation
  - Energy from absorbed photon changed to chemical energy
  - Electron of pigment moves from ground state to excited state
  - Chlorophyll is oxidized, electron acceptor is reduced
- Photosystems
  - Composition
    - Antenna complex
    - Reaction center chlorophyll
    - Primary electron acceptor
  - Photosystem I and II
- Electron flow
  - Noncyclic photophosphorylation
    - Photosystem II
      - Light absorption
      - Electron transfer from P680 to primary electron acceptor
      - Electron transfer from primary electron acceptor to electron transport chain
      - Chemiosmosis results in electron transfer to P700 of Photosystem II and production of ATP
    - Photosystem I
      - Light absorption
      - Electron transfer from P700 to primary electron acceptor
      - Electron transfer from primary electron acceptor to

ferredoxin

Electron transfer from ferredoxin to NADP+

Photosystem II completes missing electrons of P700

Cyclic photophosphorylation

Photosystem I only involved

Electrons travel different pathway through electron transport of noncyclic electron flow

Results in additional ATP production; NADPH and O_2 are not produced

Calvin cycle

Carbon fixation

Ribulose biphosphate(RuBP)

Reduction

3-phosphoglycerate reduction

ATP hydrolysis

Regeneration of RuBP

Photorespiration

Carbon fixation with minimal photorespiration

C_4 plants

Mesophyll cells

Bundle-sheath cells

CAM plants

Storage of CO_2 by organic acids

Mitosis

- Purposes
    - Reproduction
    - Growth
    - Replacement
- Eucaryote cell components
    - Chromosone
        - Location
        - Structure
        - Number present
    - DNA
        - Double stranded helix
        - Genes at specific locations
- Cell cycle
    - Definition
        - Length of cycle
        - Type of cell
        - Growth factors
        - Restriction point
        - MPF (maturation promoting factor)
        - Result of cycle
- Basic processes in cell division
    - Replication
    - Pairing
    - Alignment

Separation

Phases of continuous cell division and chromosome changes

Interphase

Periods of growth

G-1

S

G-2

Mitotic Phases

Early Prophase

Late Prophse

Metaphase

Anaphase

Telophase

Cytokenisis

Meiosis

Stages of Meiosis

Interphase I

Meiosis I-segregation of homologous pair and reduction of chromosome number by ½

Prophase I

Synapsis

Tetrad

Spindle microtubules

Disappearance of nuclear envelope

Metaphase I

Alignment of tetrads

Anaphase I

Separation of homologues

Telophase I and Cytokinesis

Chromosomes reach poles

Clevage furrows or cell plates form

Meiosis II-separation of sister chromatids

Prophase II

Chromosomes move toward center plate

Metaphase II

Chromosomes align at plate

Anaphase II

Sister chromatids separate and move toward poles

Telephase II and cytokinesis

Four haploid daughter cells form

Genetic Variation

Independent assortment

Crossing Over

Random fertilization

Mendelian Genetics

Mendel's Approach

- Blending theory of heredity
- Mendels experiments
    - Character/trait
    - True breeding plants
- Particulate theory of heredity

Law of Segregation

- Monohybrid crosses
    - F_2 ratios
    - Punnett square
- Testcross

Law of Independent Assortment

- Dihybrid cross

Rules of Probability

- Rule of multiplication
- Rule of addition

Interaction between genes

- Incomplete dominance
- Complete dominance
- Codominance
- Multiple alleles
- Epistasis

Chromosome theory of inheritance

- Linked genes
    - Sex linked genes

Independent assortment of chromosomes

Genetic recombination

Unlinked genes

Linked genes

Errors

Alteration of chromosome number

Nondisjunction

Aneuploidy

Polyploidy

Alteration of chromosome structure

Human disorders

Down syndrome

Genomic imprinting

Extranuclear genes

DNA Structure and Replication

Nucleic Acids

Atoms and characteristics

Nucleotides-monomer of nucleic acids

Composition

Pentose

Phosphate

Nitrogenous bases

Pyrimidines

Purines

Deoxyribonucleic acid (DNA)

Ribonucleic acid (RNA)

Structure-double helix

Nucleotide chains

Sugar-phosphate backbone

Base pairing

Replication of DNA

Origins of replication

Replication fork, replication bubble

DNA polymerases

Antiparallel DNA strands

Leading strand

Okazaki strand

Primer

Enzymes

Helicases

DNA polymerase

Repair enzymes

Telomeres

Protein Synthesis

Transcription in eukaryotes

- RNA polymerase binding
  - Promoters
  - Transcription factors
    - TATA box
- Elongation of RNA
  - Functions of RNA polymerase II
  - Growth of RNA
- Termination

RNA processing in eukaryote cells

- Modification of pre-mRNA ends
- RNA splicing
  - Exons versus introns

Translation in Eukaryotes

- Transfer RNA (tRNA)
  - Recognition of specific amino acids
    - Aminoacyl-tRNA synthetase
  - Ribosomes
    - tRNA anticodon base pairs with mRNA complementary base pairs
    - Eukaryotic ribosomes
    - Prokaryotic ribosomes
    - Ribosomal enzymes cause peptide linkage in growing peptid
    - Polyribosome
- Steps of translation
  - Initiation

- Small ribosomal subunit binds to mRNA and tRNA
- Large ribosomal subunit binds to form complex
- Elongation
  - Codon recognition
  - Peptide bond formation
  - Translocation
- Termination
  - Stop codon
  - Ribosome separates from tRNA and protein
  - Separation of small and large ribosome subunits
- Functional protein
  - Protein conformation
  - Post-translation modification
    - Chemical modification
    - Chain length modification

Protein destination

- Proteins synthesized by free ribosomes
- Proteins synthesized by ribosome bound to ER

Mutations in protein structure

- Point mutations
  - Base-pair substitutions
    - Missense mutation
    - Nonsense mutation
  - Insertions and deletions

Frameshift mutation

Mutagens

Prokaryotes

Phylogeny

Domain Archaea

Methanogens

Extreme halophiles

Extreme thermophiles

Domain Bacteria

Structure

Cell walls

Gram negative versus gram positive bacteria

Movement

Cellular organization

Location of cellular respiration

Location of photosynthesis in cyanobacteria

Nucleoid region

Plasmid

Reproduction

Binary fission

Generation time

Genetic recombination

Transformation

- Conjugation
- Transduction
- Endospore

Nutrition

- Photoautotrophs
- Chemoautotrophs
- Photoheterotrophs
- Chemoheterotrophs
  - Saprobes
  - Parasites
- Nitrogen cycling in ecosystems
  - Nitrogen fixation

Use of Oxygen

- Aerobes
- Anaerobes

Impact of prokaryotes

- Recycling of chemical elements
- Symbiosis
- Disease
  - Koch's postulates
  - Toxins
  - Antibiotics
    - Antibiotic resistance

Microbial Genetics

- Viruses
  - Structure
    - Genome
    - Outer enclosure
    - Bacteriophages
  - Reproduction
    - Typical life cycle
      - Host infection
      - Viral genome replication and capsid production
      - Self assembly
    - Bacteriophages
      - Lytic cycle
      - Lysogenic cycle
    - Animal viruses
      - Viral envelopes
        - Host cell plasma membrane
        - Host cell nuclear membrane
          - Provirus
      - RNA as genetic material
        - Classification based on mRNA
        - Retrovirus
      - Methods to cause disease
      - Methods to fight viral disease

- Vaccines and antiviral drugs
    - Prions
- Plant viruses
    - Effect on plants
    - Spread of virus in plant
    - Method to fight viral disease
    - Viroids
- Bacteria
    - Genome
        - Bacterial chromosone
        - Extrachromosomal DNA
    - Reproduction
        - Binary fusion
    - Genetic recombination
        - Transformation
        - Transduction
        - Conjugation
    - Antibiotic resistance
        - R plasmids
    - Transposons
    - Gene Expression
        - Operon Concept
            - Structural gene
            - Operon

- Polycistronic mRNA
- Operator
- Regulatory genes

DNA Technology

- DNA Cloning
  - Restriction enzymes
    - Recognition sequences
    - Modification of bacterial DNA
    - Restriction fragments-sticky ends
  - Process
    - Cloning vector
      - Bacteriophages
    - Steps to clone a eukaryotic gene
      - Isolate vector (bacteria plasmid) and eukaryotic DNA
      - Insert eukaryotic DNA into vector
        - Restriction enzyme
        - DNA ligase
      - Cloning vector added to bacteria culture
      - Cloning of cells
- Mapping genomes
  - Location of genes
  - Genetic mapping
    - Gene markers

- Physical mapping
    - DNA fragments
- DNA sequencing

Genome analysis

- Analysis of DNA sequences
- Gene expression
- Gene function

Biotechnology

- Diseases diagnosis
- Gene therapy
- Pharmaceutical products

Forensic DNA technology

- DNA fingerprinting

Environmental DNA technology

Agricultural DNA technology

- Animals
    - Transgenic animals
- Plants
    - Genetic engineering

Ethical concerns

CHAPTER V

Semester Two Outlines

Systematics

- History
  - Aristotle
  - Linnaeus
  - John Ray
  - Darwin
  - Phylogenetics
- Classification of species
  - Homology
  - Analogy
  - Molecular biology
    - Amino acid sequence
    - DNA sequence
    - Molecular clocks
- Classification schemes
  - Two kingdoms
  - Five kingdoms
  - Three domains
- Claudistics
  - Assumptions
  - Analysis

Location of branch points

Protista

Characteristics

Shapes

Environment and Nutrition

Candidate kingdoms

Archaezoa

Euglenozoa

Alveolata

Dinoflagellates

Apicomplexans (sporozoans)

Ciliates

Stramenophila

Diatoms

Golden Algae

Water molds

Alteration of generations

Rhodophyta

Green Algae

Other protista

Pseudopodia

Rhizopods

Actinopods

- Foraminiferans

Slime molds

Fungi

Nutrition

- Mycelium
- Parasites
- Growth rate

Reproduction

- Spores

Divisions

- Chytridiomycota
- Zygomata
- Ascomycota
- Basediomycota

Unique lifestyles

- Molds
- Yeasts
- Lichens
- Mycorrhizae

Impact on ecosystems

- Decomposers and symbionts
- Pathogens

Plant Diversity

Plant characteristics

- Multicellular eukaryotic
- Autotrophs
- Chlorophyll a & b
- Cell walls composed of cellulose
- Food stored as starch
- Cell specialization of aerial cells and subterranean cells
- Alternation of generations

Anatomical differences on phylogenic tree

- Nonvascular plants/Bryophytes characteristics: mosses, liverwort, hornwort
  - Embryophyte condition
  - Cuticle prevents water loss
  - No xylem or phloem
  - Gametophyte dominate
  - Require moisture for fertilization
- Seedless vascular plant characteristics: ferns, horsetails
  - Conducting tissue
    - -xylem and phloem
  - Require mosture for fertilization
  - Sporophyte dominant
  - Produce spores
  - Megaspore and/or microspore
  - Plants are heterosporous or homosporous
- Seed plant characteristics: seed ferns, gymnosperms, angiosperms

Sporophyte dominant

Heterosporous

Megaspore produce seed

Microspore produce pollen

Fertilization occurs in ovule

Seed

Seed coat

Embryo(2n)

Food supply

Gymnosperms-seeds do not form in ovary (naked seeds)

Conifer characteristics: pines, redwoods

Develop male and female cones

Evergreens needle like leafs

Major source of lumber

Oldest living individuals

Angiosperms-plants that flower and produce seed inside the ovary

Class Monocotyledones (monocot) or Dicotyledones (dicot)

Flower structure (modified leaves)-complete flowers

Non-reproductive

Sepals

Petals

Reproductive

Stamens: filament, anther

Carpel: stigma, style, ovary

Fruit: mature ovary

Perfect versus imperfect flower

Complete versus incomplete flower

Monoecious versus dioecious

Sexual reproduction by pollination

Cross pollination

Barriers to self pollination

Double fertilization produces endosperm and embryo

Embryo development

Cotyledons form, called first seed leaves

Monocot versus dicot embryo

Mature seed

Seed coat formed from integuments

Embryo formed from zygote

Cotyledon

Hypocotyl-below the cotyledon

Radicle-becomes the root

Epicotyle-above the cotyledon

Fruit formation may accompanies seed development

Purpose is seed dispersal

Seedling development

Imbibition

Radicle and shoot emerges from ruptured seed coat

Asexual reproduction/vegetative reproduction

Fragmentation of parent plant

Clone grows from callus

Tissue culture propagation (test tube cloning)

Clones grow from cells that form callus

Advantages and disadvantages of asexual reproduction

Plant hormones

Plant Reproduction

Pollination-transfer of pollen from anther to stigma

Self-pollination

Monoecious plants

Barriers to self pollination

Dioecious plants

Stamens and carpels mature at different times

Flower structure

Self-incompatibility

Cross-pollination

Fertilization

Double fertilization

Pollen tube grows

Two sperm cells develop

Triploid nucleus

Embryo development

Cotyledons

- Monocot
- Dicot
- Mature seed
  - Seed coat
  - Embryo
  - Cotyledon
    - Hypocotyl
  - Radicle
  - Epicotyle

Fruit

- Development

Seedling development

- Imbibition
- Radicle emerges

Morphogenesis

- Cell differentiation

Vegetative reproduction

- Cloning of plants by asexual reproduction
- Fragmentation

Plant Structure

- Plant tissue systems
  - Dermal tissue (epidermis)
    - Single layer of cells, covers the entire plant

- Vascular tissue
  - Continuous transport system consists of xylem and phloem
- Ground tissue
  - Unspecialized, thin walled parenchyma cells
  - Metabolic functions occur here ie. photosynthesis

Plant Growth

- Indeterminate growth
  - Growth of whole plant is not limited to size
  - Grows through out life span
    - Meristems-localized region of embryonic cells with active mitotic cell division
      - Apical-produce primary growth (length) in the tips of roots and shoots
      - Lateral-produce secondary growth (wood) along the length of the plant
- Determinate growth
  - Growth is limited
  - Leaves and flowers
- Life cycle length (germination to death)
  - Annuals
  - Biennial
  - Perennial
- Roots
  - Tap root

Root cap

Vascular system

Root hairs

Shoots

Vascular bundles

Nodes and internodes

Leaves

Epidermal layer covered by cuticle for prevention of water loss

Guard cells

Stomata

Ground tissue (mesophyll)-internal tissue

Parenchyma cells

Palisade parenchymas

Spongy parenchyma

Vascular tissue

Located near the chloroplasts for transport of water, minerals, sugars

Xylem

Phloem

Plant Movement

Tropisms-response to a stimulus in plants resulting in growth

Phototroism-light stimulus

The meristem shoot tip is location of light control on the plant

Auxin stimulates the growth of cells on the dark side of the shoot—curvature of the shoot

Growth inhibitors are concentrated on the light side of the shoot

Phytochrome molecule made of 2 proteins has photoreceptor functions (detect light) and kinase functions (regulatory-inhibit/activate)

Gravitropism-gravity stimulus

Germinated seed results in the roots growing down and the shoot growing up

Statholith (starch containing plastids) move with gravity

Effect movement of Ca and auxin in cell to effect growth of root

Origins of Life

The origin of life

Current theories

Spontaneous generation

Miller-Urey Model

Genetic material

Darwinism

Voyage of the Beagle

The Origin of Species

Descent with modification

Natural selection

Intelligent Design

Fossil record

- Formation of fossils
- Dating fossils
- Features
- Limitations
- Origin of man
    - Descent of Man
    - Fossil record
    - Abrupt appearance

Taxonomy

- Linnaeus

Comparative anatomy

- Homology
- Analogy
- Vestigial organs
- Embryology

Molecular biology

- Similar macromolecules
- Similar biomonomers
- Structure of genetic material
- Comparisons of molecular sequences

Speciation

- Allopatric
- Microevolution agents
    - Genetic drift

- Bottleneck effect
- Founder effect
- Natural selection

- Examples of microevolution
- Sources of genetic variation
  - Mutation

Animal Diversity

- Characteristics of animals
- Anatomical differences at branch points on phylogenetic tree
  - True tissues
  - Radiata and bilateria
  - Body cavitites
  - Protostomes and deuterostomes
- Invertebrates
- Parazoa
  - Porifera Characteristics
- Eumetazoa/Radiata
  - Cnideria Characteristics
- Aceolomates
  - Platyhelminthes (flatworm) Characteristics
- Pseudocoelomates
  - Nematoda (roundworms) Characteristics
  - Rotifer Characteristics

Coelomates/Protostomes

- Annelid Characteristics
- Mollusca Characteristics
  - Class Gastropoda
  - Class Bivalvia
  - Class Cephalopoda
- Arthropoda Characteristics
  - Trilobites
  - Chelicerates
  - Crustaceans
  - Uniramians
  - Key to insect success
    - Movement by wings
    - Excretion through Malpighian tubules of uric acid
    - Metamorphosis

Coelomates/Deuterostomes

- Echinodermata Characteristics

Phylum Chordata Characteristics

- Notocord
- Nerve cord/neural tube

Invertebrate chordates

- Subphylum Urochordate (tunicate) characteristics
- Subphylum Cephalochordates (lancelets)

Vertebrate chordate characteristics

Superclass Agnatha characteristics

Superclass Gnathostomata I

Class Chondrichthyes

Class Osteichthyes

Superclass Gnathostomata II

Class Amphibia characteristics

Class Reptilla characteristics

Class Aves characteristics

Class Mammalia characteristics

Monotremes

Tissue Types

Epithelial tissue characteristics

Simple epithelial tissues

Simple squamous-flat cells, easy gas exchange

Simple cuboidal-cube shape cells, secretion and absorption

Simple columnar-tall, elongated cells, secretion and absorption

Connective tissue characteristics

Major types

Loose connective tissue-most common, "packing material"

Fibrous connective tissue-fibers in parallel rows

Cartilage-solid but flexible

Bone-hardened by calcium

Blood-no fibers, made in bone marrow

Muscle tissue

Major types

Skeleton muscles

Cardiac muscles

Smooth muscles

Nervous System

Invertebrates

Cnideria

Nerve net-nerve cells with none to some centralization

Echinoderms

Central nerve ring

Platyhelminthes

Bilateral nerve cords, ganglia function as simple brain, eye spots

Annelids

Coordination of body segments, ganglia per segment

Arthropods

Well-developed cephalization of brain and sensory organs

Mollusca

Varies from very simple (chiton) to complex with large brain (squid)

Vertebrates (Phylum Cordata)

Characteristics

- Notocord
- Central nervous system develops from nerve cord (neural tube) into brain and spinal cord
- Peripheral nervous system consists of sensory and motor nerve cells (neurons)

Peripheral nervous system

- Somatic function
  - Skeletal voluntary muscles
- Autonomic function
  - Smooth involuntary muscles
- Autonomic divisions
  - Parasympathetic function
    - Normal body functions with minimal outside stimulus
  - Sympathetic function
    - Fight-flight response

Central nervous system

- Spinal cord characteristics
  - Located inside of vertebral column (spine)
  - Tissues include white matter in outer tissue, axon bundles and gray matter in inner tissue, cell bodies, dendrites, axons w/o myelin
  - Pairs of spinal nerves
  - Central canal with cerebral spinal fluid
  - Meninges tissue surrounds spinal cord
- Brain characteristics

Located inside skull

Tissues include white matter in inner tissue and gray matter in outer tissue

Brain stem (anterior end of spinal cord)

Consists of pons, medulla, midbrain

Hindbrain

Pons-coordinates flow of information from cerebellum to forebrain

Medulla-controls autonomic functions

Cerebellum-coordinates muscle contraction

Midbrain

Receives and interprets sensory information and sends to forebrain

Forebrain

Cerebrum

Higher mental activities

Coordination of sensory input

Limbic system

Thalamus

Center for sensory impulses to and from forebrain

Hypothalamus

Maintains homeostasis (body temperature, hunger/thirst, blood pressure)

Pineal gland

Circadian rhythms

Pituitary gland

Neuron Cells

Cell body-contains nucleus

Processes (extensions)

Dendrites-convey signals to cell body

Axon-conducts signals away from cell body

Myelin sheath-insulates axon

Schwann cells in PNS; Oligodendrocytes in CNS

Synaptic terminals-endings of axon branchs

Synapse-junction between neuron and target cell

Types of neurons

Sensory neurons

Motor neurons

Interneurons

Simple neuron circuit

Reflex-neuromuscular response to a stimulus

Ganglia in PNS bypass brain

Glia cells

Provide support to neurons

Outnumber neurons

Neural signals

Membrane potential-charge difference between insides of cell (cytoplasm) and outside of cell (extracellular fluid)

Charge inside of cell is negative , -70mV at resting membrane potential

Ions cause the difference in charges

Intracellular ions- anions: group of many ions cation: potassium

Extracellular ions-anions: chloride, cation: sodium

Potential is necessary to generate an electrical impulse

Concentration gradient causes K+ diffusion out of the cell and Na+ diffusion into the cell

Na+-K+ pump prevents loss of membrane potential

Energy is required

Action potential

Change in membrane potential from resting state in excitable cell

Change results in electrical impulse

Stimulus causes change

Voltage gated ion channels increase permeability for specific ions

Hyperpolarization

Depolarization

Depolarization reaches threshold potential (intensity of stimulus causes a response)

Refractory period occurs-neurons can not respond to stimulus

Action potential is in progress

Strength of stimulus affects the frequency of action potentials

Propagation of action potentials-adjacent area of membrane is depolarized

Saltatory conduction

Nodes (gaps) are not myelinated

Action potentials jump

Faster transmission

Synapses

Electrical

Action potential travels to adjacent neuron quickly

Chemical-most common

Influx of calcium

Synaptic vesicle with neurotransmitter fuse with membrane

Neurotransmitter released and attaches to ion channel protein

Gates open allowing influx of sodium

Voltage of post-synaptic membrane changes

Circulation

Circulatory system of invertebrates

Phyllum proifera, cnideria, phythelminthes

Gastrovascular cavity

Diffusion occurs through body walls of the thickness of a few cells

Phyllum arthropoda, mollusca

Open circulatory system results in hemolymph

Phyllum annelid, echinoderms

Closed circulatory system

Circulatory system of vertebrates

Fish

Two chambered heart with single circulation

Amphibian

Three chambered heart with double circulation

Pulmocutaneous circuit and systemic circuit

- Mammal
  - Four chambered heart with double circulation
  - Pulmonary and systemic circuit
  - Major blood vessels
    - Superior vena cava
    - Pulmonary artery
    - Pulmonary veins
    - Aorta
  - Valves
    - A-V valve
    - Semilunar valve
  - Cardiac cycle
    - Atrial and ventricular systole
    - Atrial systole/ventricular diastole
    - Ventricular systole/Atrial diastole

Electrical activity of heart

- Specialized tissue
- SA (sinoatrial) node or pacemaker
  - Located in right atrium
  - Determines rate of contractions
  - Simultaneous contraction of atria occurs
- AV (atrioventricular) node
  - Located between right atrium and ventricle
  - Slight delay of impulse

- Simultaneous contraction of ventricle occurs
- Spread of waves of excitation
  - SA node to AV node to bundle branches to Purkinje fibers
- Factors effecting AV node
  - Body temperature
  - Hormones
  - Opposing nerves

Blood pressure

- Systolic pressure-force following ventricular systole
- Diastolic pressure-force following ventricular diastole
- Arteriole wall muscles contract/relax
  - Dilation-muscles relax
  - Constriction-muscles contract
- Minimal pressure on veins
  - Peripheral resistance
  - Skeletal muscle movement

Lymphatic system

- Lymph
- Lymph vessels
- Lymph nodes

Blood components

- Plasma
- Cells
  - Erythrocytes

- Leukocytes
- Platelets

- Source of cells
  - Pluripotent stem cells

Cardiac Diseases

- Arteriosclerosis
- Heart attack
- Stroke

Excretory System

Diverse physiology of animal excretory systems

- Flame cell system (planaria)
- Metanephridia system (earthworm)
- Malpighiam system (insects)

Kidney system (human)

- External anatomy
  - Kidney organs
  - Ureters
  - Bladder
- Internal anatomy
  - Cortex
  - Medulla
  - Nephron
    - Bowman’s capsule

Proximal tubule

Loop of Henle

Distal tubule

Collecting duct

Physiology of nephron

Filtration

Reabsorption

Proximal tubule-

Loop of Henle

Ascending loop

Collecting duct

Secretion

Proximal tubule

Distal tubule

Water reabsorption regulation

Antidiuretic hormone-(ADH)

Endocrine System

Hormones

Plasma membrane receptor

Intracellular receptors-steroid hormones

Vertebrate endocrine system

Hypothalamus

Anterior pituitary gland

Growth hormone

- Thyroid stimulating hormone(TSH)
- Adrenocorticotropic hormone (ACTH)
- Male and female hormones
- Endorphins

Posterior pituitary gland

- Antidiuretic hormone (ADH)

Pineal gland

- Melatonin

Thyroid gland

- T3 and T4
- Calcitonin

Parathyroid gland

- Parathyroid hormone

Pancreas

- Insulin
- Glucagon

Adrenal Gland

- Epinephrine (adrenaline)
- Norepinephrine

Hormone control examples

- Diabetes mellitus
  - Normal control of glucose
  - Insulin dependent and non-insulin dependent
- Stress

Nervous system influence

Catecholamines (epinephrine, norepinephrine)

Hormonal influence

Corticosteroids (glucocorticoids, mineralocorticoids)

Vertebrate muscles

Muscle types

Smooth muscle (involuntary)

Skeletal muscles (voluntary)

Cardiac muscle (involuntary)

Skeletal muscle

Structure

Muscle fiber (cell) bundle

Myofibrils

Myofilaments

Actin

Myosin

Sacromere

Contraction

Sliding filament model

Sliding process

Energy source

ATP

Glycogen

Creatine phosphate

Contraction control

Motor neuron stimulation

Sarcoplasmic reticulum

Action potential

Muscle fibers as a unit

Frequency of motor neuron stimulation

Number of muscle cells stimulated

Duration of contraction

Fiber types

Respiratory system

Gas exchange in animals

Respiratory surface- exchange oxygen and carbon dioxide

Slow moving small aquatic invertebrates-skin

Larger or more active aquatic animals-gills

Counter current exchange of fish

Terresestrial animals

Tracheal respiration

Lungs

Lungs connected to air sacs

Mammalian system

Upper respiratory tract

Pharynx

- Epiglottis
- Trachea
- Lower respiratory tract
  - Bronchi to bronchioles to alveoli
  - Intercostal muscles, diaphram
  - Pleural membrane
- Inhalation
  - Negative pressure-air is pulled into lungs
  - Diaphragm contracts, intercostals muscles lift ribs
- Exhalation
  - Passive
  - Diaphragm and intercostals muscles relax
- Air Volume
  - Tidal volume-volume of air moves with inhalation/exhalation
  - Vital capacity-maximum volume of air
  - Residual volume-amount of air that remains in lungs

Diffusion of gases

- Partial pressure-pressure from a specific gas concentration
- Gas concentration changes throughout blood circulation

Transport of gases

- Respiratory pigments
  - Hemoglobin molecule can carry four oxygen molecules
  - Dissociation curve for hemoglobin-binding and release of oxygen

Small decrease in P O_2 in tissues causes a large amount of O_2 release by hemoglobin

During exercise the curve is steep due to greater use of O_2 by the cells for cellular respiration

A decrease in pH from CO_2 increases release of O_2

Transport of CO_2 , Bicarbonate buffer system

Red blood cells bind 23% of CO_2

RBCs contain carbonic anhydrase converting 70% of CO_2 into carbonic acid to bicarbonate

7% of CO_2 dissolves in blood plasma

Bicarbonate ion reaction reverses in lungs for CO_2 release

Digestion System/Nutrition

Classifications

Food consumption

Herbivores

Carnivores

Omnivores

Feeding mechanisms

Suspension-feeders

Substrate-feeders

Fluid-feeders

Bulk-feeders

Food processing

- Digestion of macromolecules
    - Fats
    - Proteins
    - Carbohydrates
- Digestion physiology diversity
    - Intracellular-occurs in vacuoles within cell
    - Extracellular-occurs outside of the cell
    - Gastrovascular cavity-single opening, enzyme secretion
    - Alimentary canal-two openings, enzyme secretion, specialized compartments

Absorption

- Small intestine
    - Anatomy
    - Circulation
        - Blood
        - Lymph system

Reabsorption of water

- Small intestine
- Large intestine

Hormonal Control

- Gastrin
- Secretin
- Cholecystokinin

Immune System

Body's defense

- First line
  - Skin, mucous membranes, secretions (ie.enzymes)
- Second line
- Phagocytic WBC (leukocytes)
  - Neutrophils-50-60%, attracted by chemical signals from cell damage
  - Monocytes-5%, develop into macrophages, many have specific locations
  - Eosinophils-1.5%, attack parasites
  - Natural killer cells-attack cells invaded by viruses
- Antimicrobial proteins
  - Serum proteins
  - Interferon
- Inflammatory response
  - Injury causes release of chemical signals
  - Dilation and increased permeability of capillaries
  - Phagocytosis by white blood cells
  - Swelling due to increased permeability of capillaries
  - Increased fever caused from toxins or pyrogens
    - Increases phagocytosis
    - Decreases growth of microbes

Third line-specific immunity

Lymphocyte (WBC called B or T cells) /antibody system

Specific antigen attaches to receptors on B cell

Clonal selection occurs –specific B cell divides

Plasma cells are produced which secrete antibodies

Primary immune response takes up to 17 days

Secondary immune response takes 2-7 days

Source of B and T cells

Lymph tissue

Self tolerance-lymphocytes do not produce antibodies against 'self-cells'

Immune response

Humoral response (antibody mediated response)

B cell activated

Antibody protection in blood and lymph

Cell mediated response

React against infected cells, cancers, tissue transplants

T cell activated

Players in immune responses

Antigen-located on cell membrane of a microbe

Antibodies-bind to antigens to increase recognition of antigen

Phagocytic WBC-recognize foreign antigen, macrophages secrete interleukin-1

Infected cell containing foreign antigens

MHC-major histocompatibility complex-displays antigen

Class I-in all nucleated cells

Class II-in macrophages, B cells, activated T cells

T cells

Tc-cytotoxic cells bind to Class I MHC

Th-helper cells activated by interleukin 1 , bind to Class II MHC antigens, release interleukin 2

Humoral immune response action by antibodies enhancing phagocytosis

Neutralization

Antibodies block antigen

Destruction by phagocytosis

Agglutination

Antibodies cause clumping

Precipitation

Antibodies form immobile precipitates

Antibodies (immunoglobulins)

Structure

Classes

IgM, IgG, IgA, IgD, IgE

CHAPTER VI

Conclusions/Discussion

In the development of this thesis two areas were approached; the identification of biology information to be included in a freshman biology course and the incorporation of case studies to provide opportunities for critical thinking.

The use of existing current biology textbooks proved useful in developing topic outlines for the course. The major topics discussed in all three texts were similar. The order of the topics also followed similar patterns in all three texts. Among these authors there was a consensus on the information to include and the order it was to be presented. There was a difference in approach to the topics. One text covered the topics in more detail than the others by providing a more in depth explanation of concepts. This has the advantages of increasing the students' understanding of a concept. At the same time it may be too overwhelming for some students.

Each major topic was reviewed in the texts to develop the student outline. Development of subject outlines was a valuable tool in the planning of specific lectures. The author found that the outline format provided several positive aspects from the viewpoint of the instructor. It provided a method to organize the sequence of information in a logical manner; the easy inclusion of visual materials to correspond to the lecture; and many terms were spelled out on the outlines that were unfamiliar to students. The outline also allowed the instructor to easily develop a list of additional terms that students should be familiar with for each lecture. In the development of exams the outline provided a guide to identify the information/concepts the instructor wished to test students on.

As a general observation the author observed that those students who did not use the outlines expressed more questions concerning the flow of information and unknown terms. Students who did not acquire the outlines prior to lectures tended to inquire about the availability for exam preparation. Students who acquired outlines prior to lecture often wrote their notes directly on the outlines.

The use of the brief case studies was manageable in the context of the lecture class time. Providing the case study in one class and completing it in the following class proved workable. The number of case studies per semester is limited by the total amount of class time. The initial intent was that students would work together in the same groups through out the semester. This proved unrealistic as a percentage of students typically dropped freshman biology courses in the first semester.

The main advantage of using case studies was the increased interaction among the students. Requiring each student to participate in the group by the assignment of questions increased group interaction. The groups allowed students to teach each other as the cases were discussed. Following group discussion, the case questions were discussed with the entire class. Students were observed to ask questions to clarify their understanding of the concepts being discussed. Students often answered other student' questions resulting in the instructor acting as a facilitator versus a lecturer.

The use of case studies was a workable tool to incorporate critical thinking exercises as defined for this thesis. The studies resulted in active participation by students through small group discussions and class discussions. To answer questions to the case studies students applied information from the lecture and text to problems.

Further work in this area would look at the development of an extended case study that would take the semester to complete; student development of questions to assigned problems; and student development of an individual case study.

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